

InterICE

Ice core storage facilities at LGGE, Grenoble, France

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The Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE-CNRS) started by the 70's, to deal with ice core and set storage facilities as deep ice core technology was developed. This corresponds to the time of the new clean room technologies became available and used for ice core processing, the analytical methods allows measurements en routine of stable isotope content of water, the low level of radioactivity, and the very low content of chemical elements and heavy metals among others in the ice.

First drilling tests have been conducted by LGGE, in Antarctica in 1972, using a thermal drill system. Follows a first 905 m deep ice core retrieved at Dome C in 1978. Since, LGGE upgraded the thermal drilling systems and conducted several tests as well as performed several electromechanical shallow cores at various locations. The collaboration with the Soviets started by 1980's, and a series of samples from Vostok, Dome B, Komsomorskaya as well as along the Mirny-Vostok route have been collected and studied. Since 1990's the international collaboration continued with Russia and USA for Vostok, and the European nations with Eurocore, then GRIP, in Greenland and now with EPICA Dome C and Dronning Maud in Antarctica. At the same time, various snow collections have been made from pits samplings and from hand drilled shallow cores. All the ice cores and pits samples have been transported from field in variable type (insulated metallic or cardboard boxes, insulated shipping container, ...) and size of insulated boxes.

In fact, LGGE accumulated in cold rooms a variety of ice cores having different diameters, variable lengths variable qualities, along with a series of various boxes from surface collections. Also ice cores are generally kept for storage as archive even a long time after completion of their study. This because advances in technique may allow measurements of new parameter of interest.

LGGE used two places for storages. One is for short-term storage, a few weeks or month, and is represented by a set of specific cold rooms inside the main building and close to laboratories where ice core are processed. The second type of storage is an area rented in a commercial warehouse and used for the long term storage.

The long term storage is rented from private company in charge of storage of frozen food products such as meat, cheese, vegetables... Two areas are used representing a total of 210 rooms for pallets (1m*1.2m*1.8m) capability. One contains 130 pallets, the second 80 pallets, and both are part of a room having a 500 pallets total capability.

The mean temperature is kept at -22°C , and this temperature is in agreement with policy for long term storage for food. However, this temperature may fluctuate with the working time as well as the cycles of defrosting, so that amplitude may reach up to 4°C for a few hours.

The storage in this type never failed in almost 30 years of use. A permanent survey 365 day a year, a double machinery for each chamber, and a back up with other rooms contribute to this safety.

For 2003, the fare for rental is 65 K€ /annum that represents an average fare of 25 €/month per pallet. This fare is supported only by CNRS (budget for infrastructure i.e. building).

On each pallet rests a set of boxes (4 to 6 depending on size and weight up to 60 kilos) containing the samples from various origin are just stacked. Each box is identified by a label with the content, the owner's name (a reference person or scientist LGGE) as well as the location of the pallet in the chamber.

Ice core sections of substantial size (a least representing one kilo of ice) are sealed in plastic bag and are placed in cardboard tubes. A frame in metal is fixed to the pallet and receive 55 cardboard tubes (1.10m long, inside diameter 12.5 cm). The tubes are lay over to make a kind of tube-wall (10 rows of 5 or 6 tubes). Two panels each side of the frame allow to close the tubes. Tubes are labelled (pallet number, row, column) and this allows a quick access to the ice samples.

Recently, LGGE received ice core boxes from EPICA ice core for laboratory and a part to be stored as an archive for future studies. The ice core samples are generally 55 cm long, and the archive represents about one fourth of the core. All cores fit the boxes (50cm*75cm *75 cm) and one box may content from 30 - 80 different samples and weigh up to 80 kilos. An area was set in one room and each box can be accessed from the shelves where they are placed by using a manual mobile lift.

The curation of the ice core samples is generally the responsibility of each research scientist who in charge of a programme (reference person). For EPICA ice core, the Science Steering Committee is the official owner and the allocation of ice samples, which are transmitted to the curator (G. Teste from LGGE) for execution and updating the ice core list.

As a summary, the ice core collection of LGGE is significant in term of volume of ice (120 pallets with tubes (6000 tubes), 450 boxes in total) and in term of activity for curation. Grenoble is 100 km from Lyon international airport accessible directly from major city but may require a stop in Paris for some other city. This has to be taken into account for the time of transport for delivery of ice cores. Renting area of a warehouse is expensive but this provides an almost the 100% requested security for long-term storage. The temperature of the storage may be a concern. The physical properties of the ice are altered because ice relaxes more rapidly as temperature is over -40°C . Also the cycles of temperature (defrosting) may produce sublimation of the ice and condensation as snow inside the plastic bag of the ice core. Time and temperature cycling may also alter content of some chemical content of the ice such as MSA, but the process is not yet established.

The way for storage in boxes on pallets, on shelves, or in tubes, has their own advantages and drawbacks. Storage in closed tubes, or better in insulated box should limit temperature variation and ice sublimation.

Long term storage of archives of ice cores in station inland Antarctica (South Pole, Vostok, the future Concordia station) where mean temperature is close to -50°C offer some advantage in this respect.

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Short report on distinctive features of the ice core laboratories in NIPR and ILTS, Japan

Reported by T. Hondoh

1. **Field Procedure:** In case of the Dome Fuji deep ice core, all core samples were vertically slit into three pieces: one for stable isotope, chemical and micro-particle analyses (sending to NIPR), another for stratigraphic analyses and physical properties (sending to ILTS), and the rest for gas analyses and preservation for future analyses (sending to NIPR and ILTS, and keeping in the site as well). All cores are packed in cardboard boxes with snow for shipping.
2. **Accession Procedure:** The two labs share the accession of the Dome Fuji core according to the policy stated above. Many ice cores recovered at different sites other than the Dome Fuji are also stored in both labs. New accessions to the labs are determined by considering the purposes and the capacities of the storages.
3. **Storage Procedure:** To keep ice core quality, the ice core lab in ILTS is equipped with a cold storage at -50°C . This temperature was determined so as to decrease the dissociation probability of hydrates smaller than 5% for ten years on the basis of the preliminary dissociation experiment.
4. **Curation Procedure:** All the Dome Fuji ice cores stored in NIPR, ILTS and the Dome Fuji are managed by both NIPR and ILTS using the common core list. After the basic analyses of the cores,

which were carried out by the project group, any proposals for the ice cores have been discussed by the steering committee named ICC (Ice Core Consortium). A researcher whose proposal is approved by ICC does sampling of the ice cores in either NIPR or ILTS according to the purpose.

5. **Deaccession Strategies:** Some old ice cores and cores under no proposals are stored in commercial storehouses in order to have enough spaces in both labs. We have no other deaccession strategies at present.
6. **Processing ice cores:** Clean condition at -10 to -20 deg C is kept by specially designed room and equipments in both labs.
7. **Shipping:** All ice cores were shipped from Antarctica to Japan by the icebreaker Shirase equipped with a cold storage at -20 deg C. In addition to this storage, a deep freezer down to -80 deg C was also used for the selected ice cores during the shipping in order to observe the effect of storage temperature.

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Ice core treatment procedure utilized by Arctic and Antarctic Research Institute (AARI) – Russian Antarctic Expedition.

Curator of Russian ice core collection:
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Field procedure for 5G and 5G-1 ice core

After each drilling run, retrieved ice core is transferred to the core storage (temperature -50...-55°C) and kept there few hours to let the drilling fluid evaporate. Then ice core is cut into 1-m pieces which are warmed up in a thermostat to the temperature of -15°C. Then, thin slices are cut from the core (along core's axis) to be measured for ¹⁰Be and isotope composition. One of the slices is used for thin section analyses. The total thickness of ice cut from the core

is about 2 cm. Then, ECM is measured continuously along the fresh flat surface of the remaining core.

The remaining part of the core is cut along its axis into two equal pieces (from the depth of 3350 m): one is kept at Vostok as an archive collection, the other has been shared between Russia, France and the USA. See the cutting plan in our presentation.

In the core storage, each piece of ice has its label at which the following information is given:

- N of SAE (Soviet Antarctic Expedition) or RAE (Russian Antarctic Expedition) (e.g., 15 SAE = 1970, 16 SAE = 1971, 45 RAE = 2000 and so on);
- Identification of borehole (e.g., 3G, 5G-1, Komsomolskaya...);
- N of 1-m piece of ice (at the same time it corresponds to the depth of the bottom of this ice core piece);
- Sometimes also the depth interval is written.

Ice core is stored in plastic bags tied with a rope. This allows eliminating the air from the bag and utilizing the bag several times.

Core storage

There are 5 core storages at Vostok Station with mean annual temperature of about -55°C in each. Two of them are at the level of snow surface and three are under snow. Ice core from all the boreholes drilled by Russian Antarctic Expedition is stored there. Low temperature allows preserving physical and chemical properties of the core for many years.

In Arctic and Antarctic Research Institute there is a cold room where small amount of core (about 2-3 boxes) can be stored.

Core accession

According to the agreement between Russia, France and the United States, ice core from 5G and 5G-1 boreholes down to the depth of 3623 m has been shared equally (50/50/50 cm) between these three countries. All the other cores retrieved or to be retrieved as a result of activity of Russian Antarctic Expedition (including new ice core to be drilled in 5G-1 borehole below 3623 m) is a property of Russian Federation.

Ice core from French and American part of 5G and 5G-1 collection is delivered to France and the US on receiving corresponding request from these countries.

For the Russian ice core collection, procedure of the access to the core is following:

Interested researcher or organization addresses the corresponding request to the Curator of Russian ice core collection. The request must contain the scientific program of the planned studies. The request is considered by commission consisting of specialists from AARI. In case of positive decision, the commission recommends delivering ice core to the researcher. Then, Director of AARI gives the corresponding order to the Curator.

Transportation

Until last year, transportation of ice core to Russia was carried out by the following way:

From Vostok ice was sent by cold deck (C-130 flight) to American McMurdo Station where it was stored in a cold storage. Then, ice was shipped to France through Christchurch (New Zealand) in refrigerators. In France, ice was stored in the cold storages of LGGE. For transportation of ice to St. Petersburg (Russia) the ship of Russian Antarctic Expedition ("Akademik Fedorov") was used. On its way back from Antarctica "Akademik Fedorov" calls the port of Bremerhavn. By the day of the ship's departure from the port, the ice was sent to Bremerhaven and delivered to the board of "Akademik Fedorov". On board, ice was stored in the refrigerators until arriving to St. Petersburg. To avoid problems with Russian customs, ice was declared as a part of scientific cargo. In St. Petersburg, ice boxes were received by people from AARI and transported to the cold rooms of AARI. Further transportation of ice samples to interested researchers is their own responsibility.

Starting from this year, transportation of ice through McMurdo is under question, so the alternative way of transportation must be found between Vostok and Europe.

Ice core processing

At Vostok, the only measurements made in the field are ECM and thin-section studies. The studies of bubble and hydrate ensembles in the Vostok core were performed on the fresh ice and ice samples stored at -55°C , which allowed to reveal the original (in situ) shape of the air inclusions and to precisely determine geometrical properties of their ensembles in ice.

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Report from the U.S. National Ice Core Laboratory for InterICE.

Todd Hinkley, Technical Director
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John Rhoades, Assistant Curator
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- 1. Field Procedure:** In the past, U.S. cores have been received from drillers and logged by contract-hire temporary workers. In future, we plan to have this work done by NICL personnel or by longer-term employees. We plan to modernize our procedures in the field, for removal of drilling fluid, logging, photographing, storage (equilibration of brittle core), containerizing for transport, and design of the field buildings. NICL staff employees will have more direct field responsibility for these kinds of core curation in the field.
- 2. Accession Procedure:** NICL is funded by the U.S. National Science Foundation and Geological Survey. It accepts and stores cores of meteoric ice, that have been drilled by those two agencies, mostly in Antarctica and Greenland. Cores are accepted with extensive documentation about drilling, site location, etc. We do not keep any cores of sea ice or sediments.
- 3. Storage Procedure:** Cores are stored in the –36°C main storage room. They are enclosed in plastic sleeves (stapled closed or heat sealed), inside aluminized cardboard tubes, on open racks. Fans run continuously in main storage to prevent temperature stratification of room air. Heat exchanger boxes are closed, by means of movable doors, during defrosting, to minimize entropy. Refrigeration is by a freon (R22) system, using reciprocating compressors.

- 4. Curation Procedure:** The NICL collection is tracked by a database, which lists locations, drilling history, cutting and sampling history, distributions of samples, and inventory remaining in the collection. Updated inventory is currently being performed. Current inventory is available on the NICL website <http://nicl.usgs.gov/>. Samples are stored in individual tubes with documentation that includes all subsequent sampling. All samples are clearly labeled with the basic information of hole, tube #, top depth, bottom depth, and orientation. Sample preservation is encouraged by using sealed bags as opposed to stapled closure as our storage facility environment encourages ablation through constant removal of water vapor through defrost cycles.
- 5. Deaccession Strategies:** When older cores are superseded by newer, better quality, better documented cores, or if cores may have been stored under suspicious conditions (viz., before coming to NICL), the criteria for taking samples from them may be relaxed. Later, such cores may be removed from the collection. The expanded list of uses for using samples from such cores include experimental large-sample-mass needs, giving samples of the cores to schools, and scientific pilot studies to refine procedures. The classification of cores as “deaccessed” has been approved by the governing board, the “Ice Core Working Group”. This board is composed of research scientists who have limited-time terms as members.
- 6. Processing ice cores:** Cores are transported from field to lab before any cutting or other processing (exceptions: n-butyl acetate drilling fluid, if used, is removed in the field; and a few samples are taken for determination of physical properties). The cores are stored in the -36°C main storage room. For processing, they are brought into the -26°C Examination Room of the lab and usually allowed to equilibrate overnight to the new temperature. A small piece (“slab”) is removed by horizontal bandsaw, cutting parallel to the core axis. The flat surface is smoothed by a planing machine. Electroconductivity measurements are done on that smoothed surface. Visual stratigraphy is performed on a collimating-light table. Further bandsaw cuts are made, by various cutting schemes, to provide samples for the distinctive needs of analysis for isotopes, major elements, trace metals, etc. Subsequent sampling is performed for gas sampling, according to the initial findings. An archive sector is

retained in most cases. Extremely sensitive sampling is performed in a Class 100 clean room that is maintained at -26°C .

7. **Shipping:** Shipping of samples of core is done routinely to labs throughout the U.S. and other countries. Insulated boxes are used, some with urethane foam insulation, some with evacuated panels. The boxes contain ice samples, eutectic bags, and small temperature loggers. Before shipping, these are kept open overnight in the -36°C freezer ("cold soaking"). Shipping is by overnight courier with "tracking" capability (usually FedEx, but other carriers have been successful), avoiding weekends and busy holiday shipping times. Larger shipments (e.g., whole new cores) are brought to the Lab by refrigerated truck, in some cases accompanied by a second, empty truck in case of mechanical or refrigeration malfunction. Dispatches and arrivals are confirmed by telephone and e-mail.